# technical manual

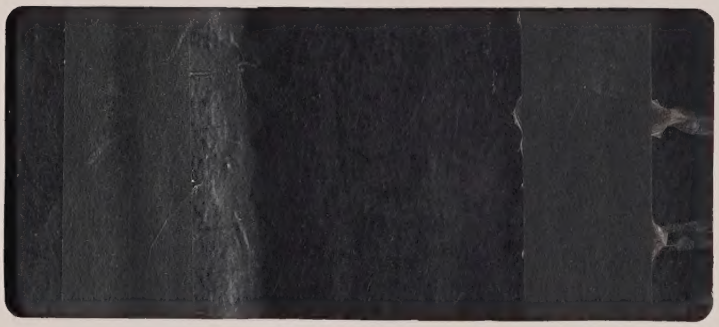
## TECHNICAL MANUAL LL33

## AC LINE REGULATORS
## L1 & L2 Product Families

MP MASTER
MA29841

TOPAZ
SOLUTIONS TO POWER PROBLEMS

3855 RUFFIN ROAD, SAN DIEGO, CALIFORNIA 92123



TOPAZ

# TECHNICAL MANUAL LL33

## AC LINE REGULATORS
## L1 & L2 Product Families

This manual covers the following models:

| | | |
|---|---|---|
| | 75101 | 77101 |
| | 75102 | 77102 |
| 73102 | 75105 | 77104 |
| 73104 | 75110 | 77108 |
| 73108 | 75197 | 77196 |
| 73198 | 75199 | 77199 |
| 73199 | 75201 | 77201 |
| 73202 | 75202 | 77202 |
| 73204 | 75205 | 77204 |
| 73208 | 75210 | 77208 |
| 73216 | 75220 | 77216 |
| 73302 | 75302 | 77302 |
| 73304 | 75305 | 77304 |
| 73308 | 75310 | 77308 |
| 73316 | 75320 | 77316 |
| 73402 | 75402 | 77402 |
| 73404 | 75405 | 77404 |
| 73408 | 75410 | 77408 |
| 73416 | 75420 | 77416 |
| 73506 | 75507 | 77506 |
| 73512 | 75515 | 77512 |
| 73606 | 75607 | 77606 |
| 73612 | 75615 | 77612 |
| 73706 | 75707 | 77706 |
| 73712 | 75715 | 77712 |

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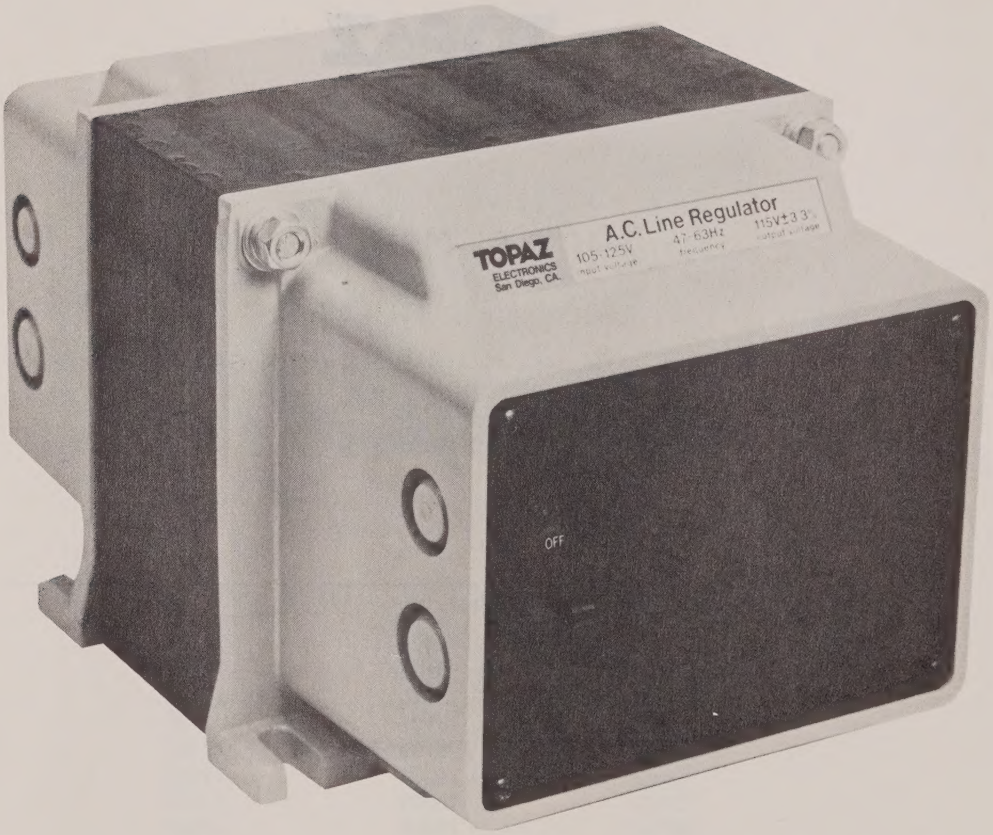


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## WARRANTY

Topaz Electronics warrants its products, when properly applied and operated under normal conditions to be free from faulty workmanship or defective materials (except in those cases where the materials are supplied by Buyer) for a period of one year (five years for standard Ultra-Isolation Transformers) from the date of original shipment. Topaz products repaired or replaced pursuant to this warranty shall be warranted for the unexpired portion of the warranty applying to the original product. The liability of Topaz under this warranty shall exist provided that:

(a) Topaz is promptly notified upon discovery of such defects by Buyer, and is allowed to inspect for defects at Buyer's site; and

(b) The defective product is returned to Topaz, transportation charges paid by Buyer, or (at Topaz's discretion) said product is inspected and repaired by Topaz at Buyer's site; and

(c) Topaz's examination of such product discloses that there was a defect in Topaz material or Topaz workmanship; and

(d) Topaz nameplates and markings have not been altered or removed.

In the event the defect is determined to be within the terms of this warranty, then Topaz agrees to repair and/or replace the product or the defective portion at no charge to the Buyer and to pay for ground transportation costs of shipment back to Buyer, or (at Topaz's option) to refund purchase price. This warranty does not apply to consumable items nor to normal wear and tear and is conditioned upon performance of normal preventative maintenance procedures and alignment.

Any technical advice furnished before or after delivery in regard to the use or application of Topaz's product is furnished without charge and on the basis that it represents Topaz's best judgment under the circumstances but it is used at the recipient's sole risk.

Topaz shall in no event be liable for other direct special, incidental, consequential, indirect or penal damages. This warranty is in lieu of all other warranties, expressed or implied, including suitability for specific use, total life expectancy, or any other obligation or liability on the part of Topaz. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF.

## NOTE

Most instances of initial failure to operate properly can be remedied through a telephone conversation between the user and Topaz Customer Service personnel. Users will be assessed recalibration and inspection charges for returned products which are found to be operating properly.

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# SECTION 1

# INTRODUCTION

## 1.1 PREFACE

### 1.1.1 SHIPPING DAMAGE

This equipment has been thoroughly tested and inspected by Topaz. While it has been packed and packaged for shipment in accordance with good commercial practice, the care exercised at Topaz does not preclude damage in transit.

The following actions should be taken upon receipt of the equipment:

a) Visually inspect for damage to the shipping container. If it is damaged, request that the carrier inspect the shipment.

b) Unpack. If the equipment is damaged, unpack in the presence of the carrier's inspector and take photos if appropriate. A full report of the damage should be obtained by the claim agent and forwarded to Topaz. If the equipment is undamaged, or only superficially damaged, test to confirm proper operation.

c) Notify Topaz within ten days after delivery if the equipment has been received in a damaged condition. After the inspection and examination by a representative of the carrier and (if necessary) an inspection and examination by a representative of Topaz and the receipt of a full report of the damage, Topaz will advise the customer on proper procedures to follow, including return to the factory (if necessary).

### 1.1.2 PROPRIETARY NOTICE

The information disclosed in this manual was originated by and is the property of Topaz Electronics. Reproduction of drawings or schematics associated with this equipment and use of patented circuitry without written permission, in advance, from an officer of Topaz Electronics is forbidden.

## 1.2 SCOPE OF MANUAL

This manual describes two families of AC Line Regulators manufactured by Topaz Electronics. It contains installation, operating, maintenance and adjustment instructions, theory of operation and circuit description, troubleshooting guides and drawings which will aid the user in understanding the equipment.

### 1.2.1 FAMILY GROUPS

The Topaz AC Line Regulator product line covers a very wide range of power ratings in various configurations. Differences in circuit design, operation, and mechanical assembly dictate that several different product families should exist for efficient change control and relative simplicity of technical manuals. Prior to applying the information in this manual to a particular model, please check to be certain that the part number of the line regulator matches one of the part numbers listed in the table on the title page of this manual.

## SECTION 2

## GENERAL DESCRIPTION

The Topaz Line Regulator is an ultra-efficient, solid-state AC line regulator. It employs all silicon semiconductors and computer grade components for utmost reliability. CMOS digital logic in the control circuit yields high noise immunity with low power dissipation. The regulation, outstanding efficiency, low distortion and small size are achieved through the use of a unique primary switching circuit which continuously monitors the input voltage and automatically terminates a primary winding of a regulating transformer. The primary switching is accomplished near zero voltage crossing so that minimum switching noise is generated. The regulating transformer operation is similar to that of an autotransformer, and is designed for excellent load regulation. Easy-to-service modular construction is employed. Overload protection is provided by circuit breakers and fuses. The regulator operates over a wide range of frequencies and power factors.

### 2.1 FEATURES

Several features distinguish Topaz Line Regulators from other line regulators available. Notable among these are:

very high efficiency
very fast response
very low distortion
very small size

## SECTION 3

## SPECIFICATIONS

This section defines the salient characteristics of the Topaz L1 & L2 families of AC line regulators.

### 3.1 INPUT SPECIFICATIONS

#### 3.1.1 INPUT FREQUENCY

47 to 63 Hz, sinusoidal with less than 10% distortion.

#### 3.1.2 EFFICIENCY

98% minimum at full load.

#### 3.1.3 LOW VOLTAGE PROTECTION

At input voltage levels that are too low for the control circuit to function properly, the regulator delivers the input directly to the output with a one to one voltage ratio.

### 3.2 OUTPUT SPECIFICATIONS

#### 3.2.1 OUTPUT FREQUENCY

Always equal to input frequency.

#### 3.2.2 OUTPUT DISTORTION

Input distortion plus 0.1% maximum.

#### 3.2.3 OUTPUT LINE REGULATION

± 3.3% maximum for 73000 series.
± 5% maximum for 75000 series.
± 7% maximum for 77000 series.

#### 3.2.4 OUTPUT LOAD REGULATION

1.0% maximum, no load to full load.

#### 3.2.5 LOAD POWER FACTOR

0.7 leading to 0.7 lagging

### 3.3 GENERAL SPECIFICATIONS

#### 3.3.1 TEMPERATURE COEFFICIENT

0.05%/°C maximum.

#### 3.3.2 INSULATION DIELECTRIC STRENGTH

1500 VRMS from input to chassis and output to chassis.

#### 3.3.3 REGULATION RESPONSE TIME

Between one-quarter cycle and one cycle of the input frequency.

### 3.4 POWER RATING AND INPUT AND OUTPUT VOLTAGES

See Table 3-1.

### 3.5 SIZES

See Installation Drawings and Table 3-1.

### 3.6 STANDARD OPTIONS

No optional configurations or optional performance specifications are offered as standard options in these product families. Modifications of various kinds are available; for further information please contact Topaz.

Table 3-1. Power Rating, Input Voltage Range, and Output Voltage.

| LINE REGULATOR PART NO. | POWER | INPUT VOLTAGE RANGE MINIMUM | INPUT VOLTAGE RANGE MAXIMUM | OUTPUT VOLTAGE | PACKAGE* |
|---|---|---|---|---|---|
| | | 73000 SERIES, SINGLE-PHASE | | | |
| 73198 | 800VA | 105V | 125V | 115V | A |
| 73199 | 1500VA | 105V | 125V | 115V | A |
| 73102 | 2kVA | 105V | 125V | 115V | B |
| 73202 | 2kVA | 202V | 239V | 220V | F |
| 73302 | 2kVA | 211V | 250V | 230V | F |
| 73402 | 2kVA | 220V | 260V | 240V | F |
| 73104 | 4kVA | 105V | 125V | 115V | C |
| 73204 | 4kVA | 202V | 239V | 220V | I |
| 73304 | 4kVA | 211V | 250V | 230V | I |
| 73404 | 4kVA | 220V | 260V | 240V | I |
| 73108 | 8kVA | 105V | 125V | 115V | G |
| 73208 | 8kVA | 202V | 239V | 220V | J |
| 73308 | 8kVA | 211V | 250V | 230V | J |
| 73408 | 8kVA | 220V | 260V | 240V | J |
| 73216 | 16kVA | 202V | 239V | 220V | G |
| 73316 | 16kVA | 211V | 250V | 230V | G |
| 73416 | 16kVA | 220V | 260V | 240V | G |
| | | 73000 SERIES THREE-PHASE | | | |
| 73506 | 6kVA | 105V | 125V | 115/199 | P |
| 73606 | 6kVA | 202V | 239V | 220/381 | Q |
| 73706 | 6kVA | 211V | 250V | 230/398 | Q |
| 73512 | 12kVA | 105V | 125V | 115/199 | K |
| 73612 | 12kVA | 202V | 239V | 220/381 | R |
| 73712 | 12kVA | 211V | 250V | 230/398 | R |

*See Installation Drawings for details.

Table 3-1. Power Rating, Input Voltage Range, and Output Voltage (Continued)

| LINE REGULATOR PART NO. | POWER | INPUT VOLTAGE RANGE MINIMUM | INPUT VOLTAGE RANGE MAXIMUM | OUTPUT VOLTAGE | PACKAGE* |
|---|---|---|---|---|---|
| | | 75000 SERIES, SINGLE-PHASE | | | |
| 75197 | 700VA | 96V | 126V | 120V | A |
| 75199 | 1300 VA | 96V | 126V | 120V | A |
| 75101 | 1.5kVA | 96V | 126V | 120V | B |
| 75102 | 2.5kVA | 96V | 126V | 120V | C |
| 75201 | 1.5kVA | 176V | 231V | 220V | T |
| 75202 | 2.5kVA | 176V | 231V | 220V | D |
| 75302 | 2.5kVA | 184V | 242V | 230V | D |
| 75402 | 2.5kVA | 192V | 252V | 240V | D |
| 75105 | 5kVA | 96V | 126V | 120V | E |
| 75205 | 5kVA | 176V | 231V | 220V | F |
| 75305 | 5kVA | 184V | 242V | 230V | F |
| 75405 | 5kVA | 192V | 252V | 240V | F |
| 75110 | 10kVA | 96V | 126V | 120V | G |
| 75210 | 10kVA | 176V | 231V | 220V | G |
| 75310 | 10kVA | 184V | 242V | 230V | G |
| 75410 | 10kVA | 192V | 252V | 240V | G |
| 75220 | 20kVA | 176V | 231V | 220V | G |
| 75320 | 20kVA | 184V | 242V | 230V | G |
| 75420 | 20kVA | 192V | 252V | 240V | G |
| | | 75000 SERIES, THREE-PHASE | | | |
| 75507 | 7.5kVA | 96V | 126V | 120/208V | K |
| 75607 | 7.5kVA | 176V | 231V | 220/381V | L |
| 75707 | 7.5kVA | 184V | 242V | 230/398V | L |
| 75515 | 15kVA | 96V | 126V | 120/208V | M |
| 75615 | 15kVA | 176V | 231V | 220/381V | N |
| 75715 | 15kVA | 184V | 242V | 230/398V | N |

*See Installation Drawings for details.

Table 3-1. Power Rating, Input Voltage Range, and Output Voltage (Continued)

| LINE REGULATOR PART NO. | POWER | INPUT VOLTAGE RANGE MINIMUM | INPUT VOLTAGE RANGE MAXIMUM | OUTPUT VOLTAGE | PACKAGE* |
|---|---|---|---|---|---|
| | | 77000 SERIES, SINGLE-PHASE | | | |
| 77196 | 600VA | 85V | 125V | 117V | A |
| 77199 | 1200VA | 85V | 125V | 117V | A |
| 77101 | 1kVA | 85V | 125V | 117V | B |
| 77102 | 2kVA | 85V | 125V | 117V | C |
| 77201 | 1kVA | 160V | 235V | 220V | T |
| 77202 | 2kVA | 160V | 235V | 220V | D |
| 77302 | 2kVA | 167V | 246V | 230V | D |
| 77402 | 2kVA | 175V | 255V | 240V | D |
| 77104 | 4kVA | 85V | 125V | 117V | E |
| 77204 | 4kVA | 160V | 235V | 220V | F |
| 77304 | 4kVA | 167V | 246V | 230V | F |
| 77404 | 4kVA | 175V | 255V | 240V | F |
| 77108 | 8kVA | 85V | 125V | 117V | G |
| 77208 | 8kVA | 160V | 235V | 220V | G |
| 77308 | 8kVA | 167V | 246V | 230V | G |
| 77408 | 8kVA | 175V | 255V | 240V | G |
| 77216 | 16kVA | 160V | 235V | 220V | G |
| 77316 | 16kVA | 167V | 246V | 230V | G |
| 77416 | 16kVA | 175V | 255V | 240V | G |
| | | 77000 SERIES, THREE-PHASE | | | |
| 77506 | 6kVA | 85V | 125V | 117/203V | K |
| 77606 | 6kVA | 160V | 235V | 220/381V | L |
| 77706 | 6kVA | 167V | 246V | 230/398V | L |
| 77512 | 12kVA | 85V | 125V | 117/203V | M |
| 77612 | 12kVA | 160V | 235V | 220/381V | N |
| 77712 | 12kVA | 167V | 246V | 230/398V | N |

*See Installation Drawings for details.

## SECTION 4

## INSPECTION, INSTALLATION AND OPERATION

### 4.1 INSPECTION UPON RECEIPT

Carefully inspect both the line regulator and its shipping container for evidence of damage sustained in shipping. If there is evidence of such damage, contact the shipping company in accordance with the instructions in the preface of this manual.

### 4.2 INSTALLATION REQUIREMENTS

#### 4.2.1 COOLING CONSIDERATIONS

Topaz AC line regulators must be installed so that unrestricted natural convection cooling is available. Do not install this equipment in unusually dirty or oily environments or where it is likely to become covered by anything which might restrict airflow.

#### 4.2.2 POWER SOURCE AND WIRING

When the line voltage is low and the line regulator is stepping up the voltage, its input current is higher than the output current by an amount proportional to the step-up. It is necessary, therefore, that the power source be capable of supplying a slightly higher current than would normally be required for a given power level. Table 4-1 is a listing of maximum input currents for Topaz line regulators in the L2 product family. In all cases, input wiring should be sized according to input current as specified in this table and in compliance with applicable electrical codes.

### 4.3 INSTALLATION PROCEDURE

#### 4.3.1 DESK-TOP MODEL INSTALLATION

Simply plug the AC line regulator into a suitable wall socket, verify that the load power requirements are within the regulator's rating, plug the load into the regulator, and turn the power switch to "ON."

#### 4.3.2 ELECTRICAL CONNECTIONS FOR OTHER MODELS

1. Switch circuit breaker to "OFF."
2. Remove cover.
3. Be sure that AC power line input wires are not connected to the power source.
4. Connect AC line power input (AC), neutral (ACC) and ground (identified by chassis ground symbol) to corresponding terminals on the terminal block, as identified on the inside of the line regulator's cover.
5. Connect load output (AC), neutral (ACC) and ground (identified by chassis ground symbol) from the terminal block as identified on the regulator.
6. Install cover on regulator.
7. Connect AC line power to the AC input power wires.

#### 4.3.3 FUNCTIONAL CHECK

1. Switch circuit breaker or power switch to "ON."
2. In case of fuse failure, check all input and output connections and check for possible overload conditions. Replace fuses only with specified types.
3. Verify that the output voltage of the line regulator is within the specified range.

#### 4.3.4 INSTALLATION TROUBLESHOOTING

If the regulator does not operate or fails to operate properly, refer to Section 7, paragraph 7.5.

### 4.4 OPERATION

Topaz AC line regulators are designed for completely automatic operation after installation and initial functional check. There are no controls or adjustments and no monitoring of operation is required.

Table 4-1. Maximum Input Current for L2 Family Regulators

| SERIES | NOMINAL OUTPUT VOLTAGE | OUTPUT POWER SINGLE-PHASE / THREE-PHASE | 1-1.5kVA – | 2kVA 6-7.5kVA | 4-5kVA 12-15kVA | 8-10kVA | 16-20kVA |
|---|---|---|---|---|---|---|---|
| 73000 | 115V | | | 19A | 38A | 77A | – |
| 73000 | 220V | | | 10A | 20A | 40A | 80A |
| 73000 | 230V | | – | 10A | 19A | 38A | 77A |
| 73000 | 240V | | – | 10A | 19A | 38A | 74A |
| 75000 | 120V | | 16A | 25A | 50A | 105A | – |
| 75000 | 220V | | 9A | 14A | 28A | 57A | 114A |
| 75000 | 230V | | | 14A | 27A | 55A | 110A |
| 75000 | 240V | | – | 13A | 26A | 53A | 104A |
| 77000 | 117V | | 12A | 24A | 48A | 95A | – |
| 77000 | 220V | | 7A | 13A | 25A | 51A | 101A |
| 77000 | 230V | | | 13A | 25A | 49A | 96A |
| 77000 | 240V | | | 12A | 24A | 47A | 94A |

SECTION 5

# THEORY OF OPERATION

## 5.1 GENERAL

A Topaz AC line regulator consists of a transformer which provides the regulated output voltage, a power module that activates a selected tap on the transformer, and a control assembly which senses the input voltage, determines which tap of the transformer should be activated, and provides appropriate drive to the power module.

At input voltages moderately below rated minimum, the line regulator will boost the voltage by the tap ratio. At input voltages greatly below the rated minimum the regulator will shift operating mode and provide a one to one voltage ratio.

## 5.2 73000 SERIES THEORY OF OPERATION

In the 73000 series line regulators the regulating transformer is configured such that it can step the input voltage up, leave it unchanged, or step it down.

When a low input voltage is present, transformer tap 1 is selected, stepping up the input voltage. When a normal input voltage is present, tap 3 is selected, shorting out the transformer. In this case the output is approximately equal to the input. When a high input voltage is present, tap 2 is selected, stepping down the input voltage.

Figure 5-1 is a simplified block diagram of a low voltage 73000 series line regulator.

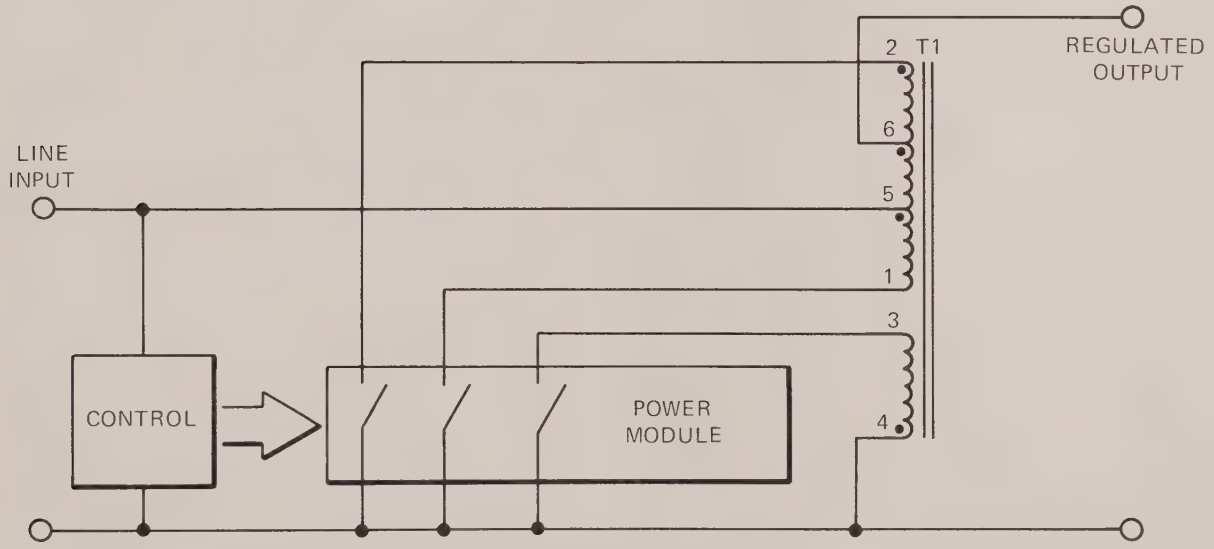


Figure 5-1. Block Diagram Low Voltage 73000 Series

The high voltage 73000 series regulators operate the same as the low voltage units with the exception that an autotransformer (T2) is used to reduce the voltage applied to the power module.

Figure 5-2 is a simplified block diagram of a high voltage 73000 series line regulator.

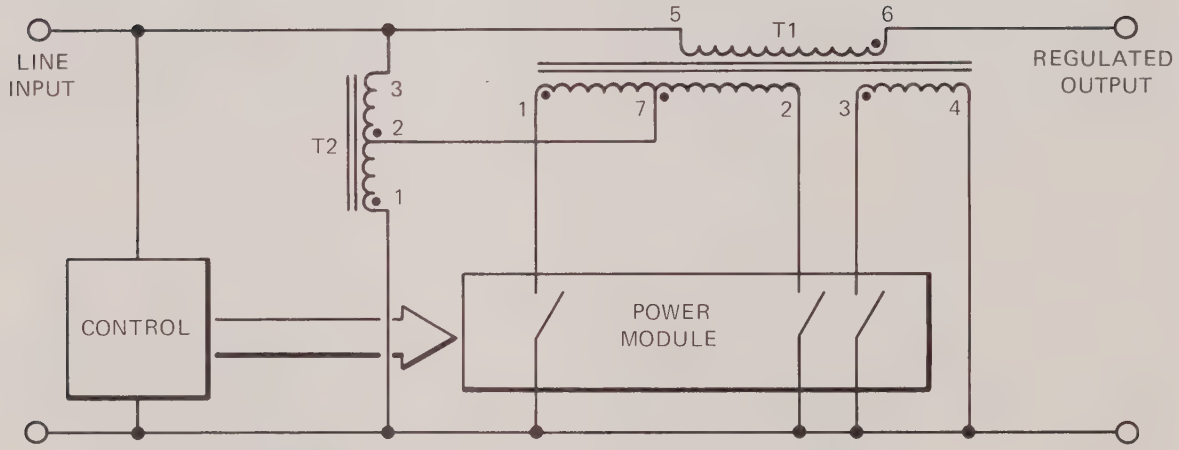


Figure 5-2. Block Diagram – High Voltage 73000 Series

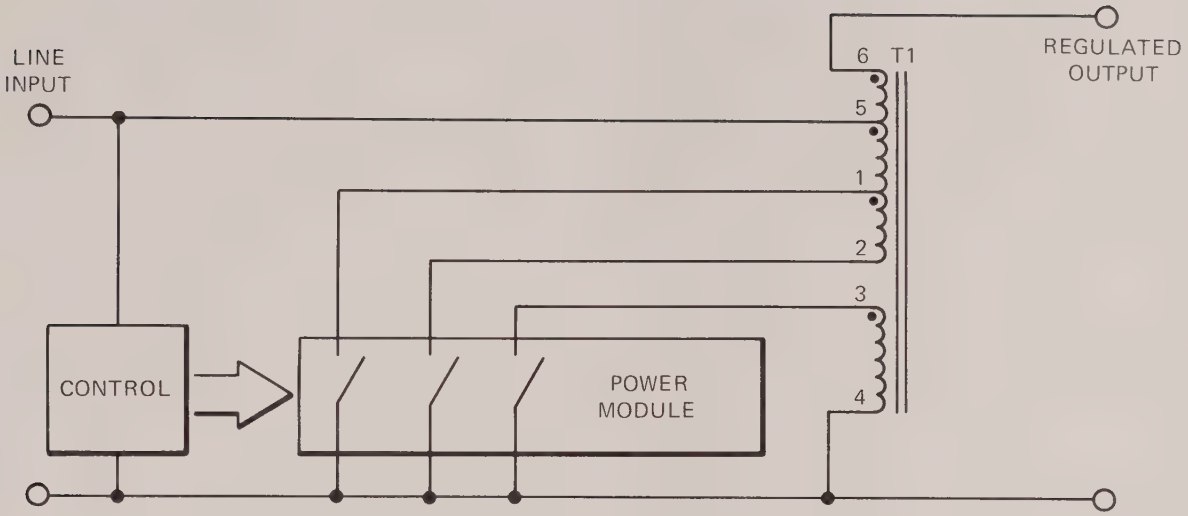


Figure 5-3. Block Diagram – 75000 and 77000 Series

## 5.3 75000 AND 77000 SERIES THEORY OF OPERATION

The 75000 series and 77000 series operate alike. The only difference between the 75000 series and the 77000 series is the turns ratio of the transformer. In Figure 5-3 it can be seen that these regulators can either step up the input voltage or pass it directly through to the output with no change. The 75000 series and 77000 series regulators have no provision for reducing the input voltage.

The power module is a three channel AC switch. When very low input voltages are present, transformer tap 1 is selected, providing the greatest step-up of the input voltage. When the input voltage is moderately low, transformer tap 2 is selected, providing moderate step-up of the input voltage. When normal input voltages are present, transformer tap 3 is selected, in effect shorting out the transformer. When tap 3 is selected the output voltage is approximately equal to the input voltage.

## 5.4 CONTROL CIRCUIT THEORY OF OPERATION

The control circuit's functions are to measure the input voltage, determine which tap of the regulating transformer should be selected, and provide the proper drive to the power module. The control circuit also has phase sensing circuits that control the timing of tap changes. It also has a system shutdown feature that is active from the time that the input switch is closed to the time that the control power supply comes up to full voltage (about 100 ms). The system shutdown is also activated whenever the input voltage is so low that the control circuit cannot function properly. (This is always well below the minimum rated input voltage.) When the system shutdown is activated, transformer tap 3 is always selected, shorting out the transformer and causing the output to be equal to the input.

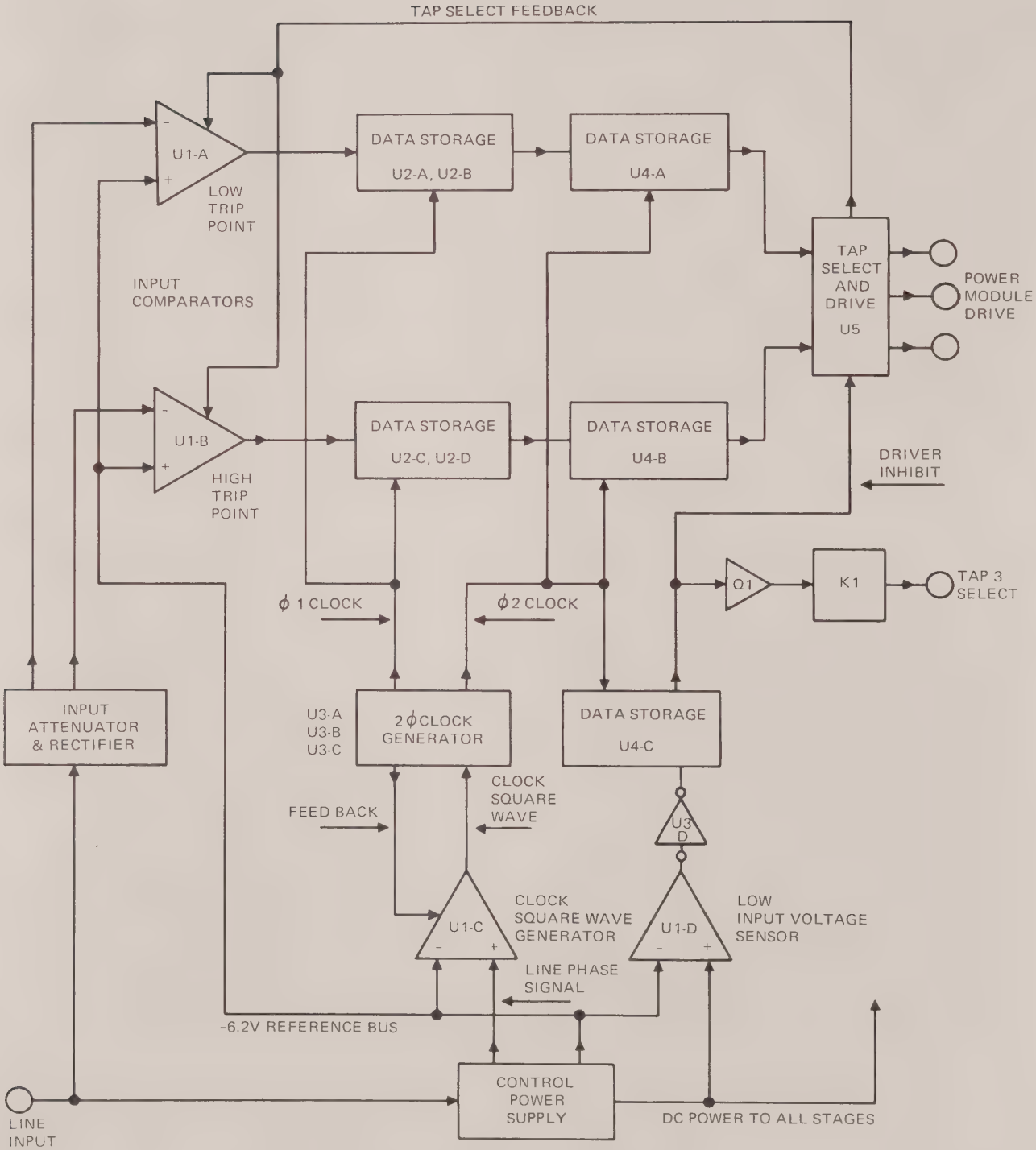


Figure 5-4. Control Circuit Block Diagram

### 5.4.1 CONTROL CIRCUIT BLOCK DIAGRAM

Figure 5-4 is a simplified block diagram of the control circuit.

The CONTROL POWER SUPPLY provides operating power to all stages. It also generates a dc reference voltage that is used in various parts of the system. The control power supply also provides a phase reference signal to the clock square wave generator.

The CLOCK SQUARE WAVE GENERATOR is a comparator that compares the line phase signal with a dc reference voltage. It generates a rectangular wave that goes low shortly after the positive-to-negative zero crossing of the input line voltage. Its output goes high about one millisecond prior to the negative-to-positive zero crossing of the input line voltage.

The clock square wave generator drives the TWO PHASE CLOCK GENERATOR. The phase 1 clock pulse is generated when the clock square wave generator's output goes low. The phase 2 clock pulse is generated when the clock square wave generator's output goes high. The pulse width of both clock phase 1 and phase 2 is on the order of 25 microseconds.

The input line voltage is attenuated and half wave rectified, then applied to the INPUT COMPARATORS where it is compared to a dc reference. The input comparators generate a high output if the negative peak of the input line voltage goes more negative than a preset value.

The signals from the input comparators are high only for the time that the instantaneous value of the input voltage is more negative than a pre-set level. For this reason DATA STORAGE is provided by U2. U2-A and U2-B are connected to form an "R-S" type flip-flop which stores data from the low trip point input comparator (U1-A). The flip-flop is set by a high signal from U1-A and reset at the start of each negative half cycle of input line voltage by clock phase 1. U2-C and U2-D perform the same function for the data from the high trip point input comparator (U1-B).

U4-A and U4-B provide a second level of DATA STORAGE. They are "D" type flip-flops and are clocked by clock phase 2 such that they can only change state when a new tap is to be selected and then only when the input line voltage reaches the proper phase.

The data stored in U4-A and U4-B is decoded by U5 (TAP SELECT AND DRIVE) which provides drive to the static tap switches in the power module. The data is also fed back to the input comparators to prevent hunting between taps.

The LOW INPUT VOLTAGE SENSOR (U1-D) senses the output voltage of the control power supply. Its output is high if the supply voltage is too low to run the control circuit. This signal is inverted and sent to U4-C. This data is clocked into U4-C by clock phase 2. It is then sent to U5 where it inhibits normal power module drive. It also opens K1 which forces selection of tap 3.

The line regulator timing diagram (figure 5-5) illustrates the time relationship of the various signals present in the line regulator.

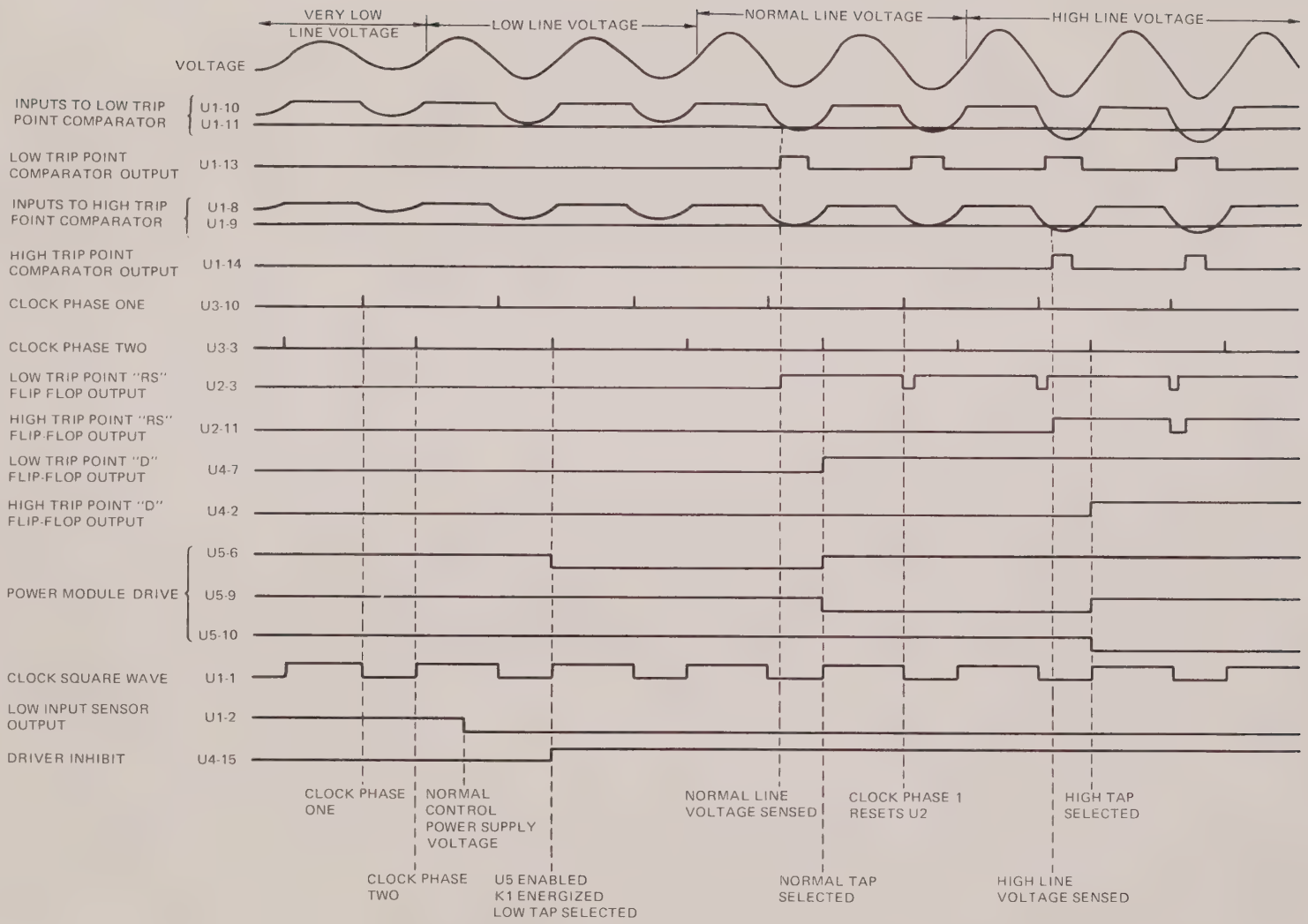


Figure 5-5. Line Regulator Timing Diagram

## 5.5 POWER MODULE THEORY OF OPERATION

Two basic configurations of power modules are used in Topaz line regulators. One uses SCR's connected inverse-parallel to switch the taps of the regulating transformer. The other uses triacs for this purpose. Power modules with suffixes –01, –02, –03, –05, and –09 use triacs for tap switches. Power modules –06, –07, and –08 use SCR's. Figure 1 on Drawing 902-15915 is the schematic for SCR power modules; Figure 2 is for triac power modules. Figure 5-6 shows the locations of SCR's and triacs in the various power modules.

Table 5-1 shows which power modules (by dash numbers) are used in various line regulators.

### 5.5.1 SCR POWER MODULE THEORY OF OPERATION

The SCR power module consists of three static switches that correspond to the three taps on the regulating transformer. Refer to drawing 902-15915, Figure 1. The circuits which terminate at E1 and E2 are identical. The circuit which terminates at E3 is the same except for the addition of Q11 and its associated components.

The circuit for E1 will be described. When tap 1 is to be selected, the control assembly draws a negative current from the gate of Q7. This turns Q7 on and current flows from E5 through Q7 to the gate of Q8. This turns Q8 on. When Q8 turns on it provides a path for gate current for either Q1 or Q2, depending on the polarity of the voltage at E1. If E1 is positive, gate current flows from E1 through CR1 and Q8 to the gate of Q2. If E1 is negative, gate current flows from E4 through CR2 and Q8 to the gate of Q1. C1 and R12 form a snubber that protects the circuit from high dv/dt.

Tap 3, which is connected to E3, must be turned on at all times when the control power supply voltage is too low for proper operation. This occurs at turn-on while the control power supply is coming up and when the input voltage is very low (much below rated minimum rated voltage). Q11 is used to accomplish this. During normal operation K1 in the control assembly shorts the gate of Q11 to ground, holding it off. When the control power supply voltage is low, K1 opens. Gate current is then provided to Q11 from E3 through R11 and C4. This turns Q11 on which turns Q13 on, which then turns Q5 and Q6 on alternately.

### 5.5.2 TRIAC POWER MODULE THEORY OF OPERATION

The triac power module consists of three static switches that correspond to the three taps on the regulating transformer. Refer to drawing 902-15915, Figure 2. The circuits which terminate at E1 and E2 are identical. The circuit which terminates at E3 is the same except for the addition of Q7 and its associated components.

The circuit for E1 will be described. When tap 1 is to be selected, the control circuit draws a negative gate current from Q4. This turns Q4 on and allows current to flow from E1 through R4 and Q4 to the gate of Q1. This turns Q1 on, connecting tap 1 to common. C1 and R5 form a snubber that protects the circuit from high dv/dt.

Tap 3, which is connected to E3, must be turned on at all times that the control power supply voltage is too low for proper operation. This occurs at turn-on while the control power supply is coming up and when the input voltage is very low (much below rated minimum rated voltage). Q7 is used to accomplish this. During normal operation K1 in the control assembly shorts the gate of Q7 to the ground, holding it off. When the control power supply voltage is low, K1 opens. Gate current is then provided to Q7 from E3 through R14 and C4. This turns Q7 on which in turn, turns Q3 on, which connects tap 3 to common.

Table 5-1. Line Regulator Power Modules

| LINE REGULATOR PART NUMBER | POWER MODULE DASH NUMBER |
|---|---|
| 73102 | -02 |
| 73104 | -02 |
| 73108 | -09 |
| 73198 | -02 |
| 73199 | -02 |
| 73202 | -02 |
| 73204 | -02 |
| 73208 | -05 |
| 73216 | -08 |
| 73302 | -02 |
| 73304 | -02 |
| 73308 | -05 |
| 73316 | -08 |
| 73402 | -02 |
| 73404 | -02 |
| 73408 | -05 |
| 73416 | -08 |
| 73506 | -02 |
| 73512 | -02 |
| 73606 | -02 |
| 73612 | -02 |
| 73706 | -02 |
| 73712 | -02 |

| LINE REGULATOR PART NUMBER | POWER MODULE DASH NUMBER |
|---|---|
| 75101, 77101 | -01 |
| 75102, 77102 | -03 |
| 75105, 77104 | -06 |
| 75110, 77108 | -07 |
| 75197, 77196 | -01 |
| 75199, 77199 | -01 |
| 75201, 77201 | -02 |
| 75202, 77202 | -02 |
| 75205, 77204 | -04 |
| 75210, 77208 | -08 |
| 75220, 72216 | -08 |
| 75302, 77302 | -02 |
| 75305, 77304 | -04 |
| 75310, 77308 | -08 |
| 75320, 77316 | -08 |
| 75402, 77402 | -02 |
| 75405, 77404 | -04 |
| 75410, 77408 | -08 |
| 75420, 77416 | -08 |
| 75507, 77506 | -03 |
| 75515, 77512 | -06 |
| 75607, 77606 | -02 |
| 75615, 77612 | -04 |
| 75707, 77706 | -02 |
| 75715, 77712 | -04 |

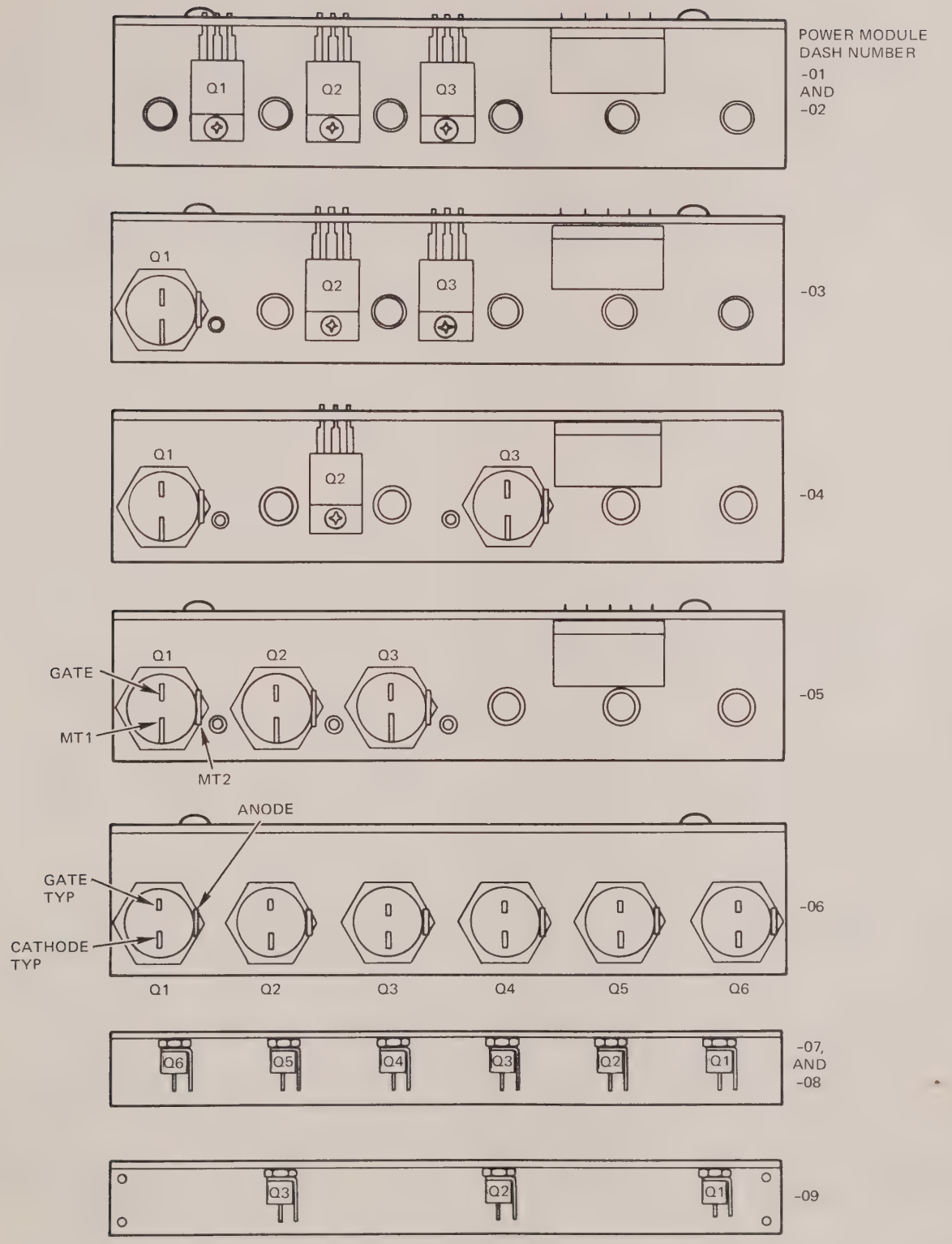


Figure 5-6. Tap Switch Locations

## 5.6 THREE-PHASE LINE REGULATORS

Topaz three-phase line regulators consist of three single-phase regulators on a common base. They are connected for four wire wye input and output. They have a common three pole circuit breaker at the input, but each phase regulates its line to neutral voltage independently of the other two. Figure 5-7 shows the interconnection of the three single-phase regulators.

Each of the single-phase regulators which make up the three phase regulator has a built-in protection circuit. This circuit causes the selection of tap 3 on its regulating transformer whenever the control power supply voltage is too low for proper operation. This condition occurs from the time that input power is applied to the time that the control power supply comes up to normal voltage. It can also occur if the input line voltage is considerably lower than the rated minimum.

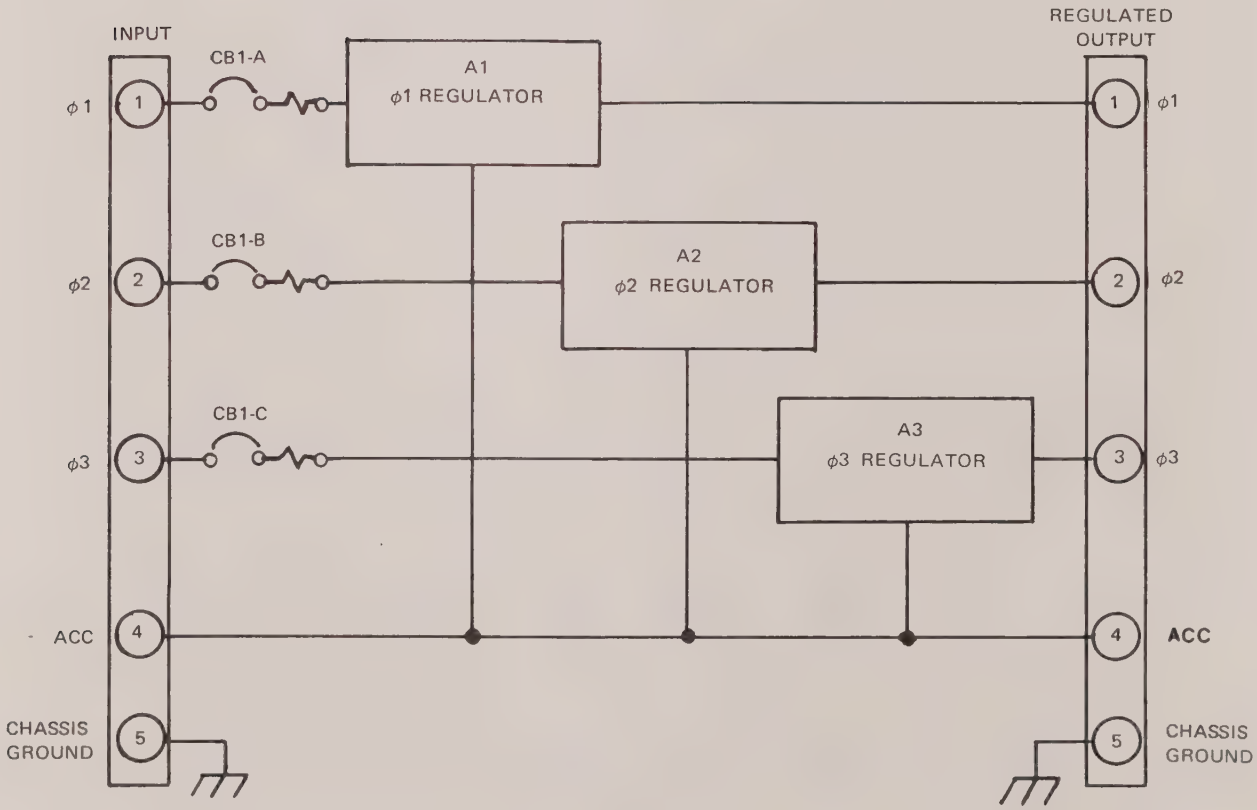


Figure 5-7. Connection Diagram for Three-Phase Line Regulators

# SECTION 6

# MAINTENANCE

## 6.1 SERVICE AND FACTORY REPAIR

### 6.1.1 SERVICE INFORMATION

Questions concerning the operation, repair or servicing of this equipment should be directed to the Topaz field representatives or to Customer Service at the factory.

**NOTE**

Please include the model number and/or part number and serial number in any correspondence concerning this equipment.

### 6.1.2 FACTORY REPAIR

Should it be necessary to return this equipment to the factory for repair, contact Customer Service at Topaz for authorization to make shipment. See the "Preface" at the front of this manual for terms of warranty and charges for unnecessary factory checkout.

## 6.2 PERIODIC MAINTENANCE

The equipment should be periodically checked to insure that the cooling air intake and exhaust areas are free of accumulations of dust and lint particles. Clean blocked areas with compressed air or with a soft brush. No further maintenance is required.

## 6.3 ADJUSTMENT AND CALIBRATION

After it has been determined that the regulator is operating properly, calibration may be checked. Calibration is always conducted without load connected to the regulator.

### 6.3.1 GENERAL CALIBRATION PROCEDURE

The general procedure is to vary the input voltage over the input voltage range and observe that the taps are changed at the proper points, thus keeping the output voltage within the specified range.

Table 6-1 gives calibration specifications for Topaz line regulators.

### 6.3.2 CALIBRATION

To calibrate the line regulator:

1. Connect a variable AC voltage source to the input terminals.

2. Connect a digital AC voltmeter to the output terminals.

3. Energize the input and vary the input voltage over the range specified in Table 6-1.

4. Observe that the output voltage stays within the limits specified in Table 6-1.

5. If the output voltage is beyond the specified limits, the trip points must be adjusted. A2R1 adjusts the low trip point – the voltage at which the first tap change occurs. A2R4 adjusts the high trip point – where the second tap change occurs. A clockwise adjustment causes the tap change to occur at a higher input voltage.

#### 6.3.2.1 Tap Change Voltages

Table 6-2 gives the approximate input voltages at which tap changes should occur to yield the proper regulation. These values are approximate; they are listed only to aid in the calibration. There will be a slight difference between trip point voltages for increasing voltages and decreasing input voltages because of hysteresis built into the control circuits. Table 6-2 lists tap change voltages for increasing input voltages.

First, adjust the trip points to the voltages listed in Table 6-2, being careful to observe and set tap change voltages only while increasing the input voltage (never while decreasing the input voltage). Then double-check to see that the output voltage stays within the specified limits as a slight touch-up adjustment may be necessary.

Table 6-1. Line Regulator Calibration Specifications

| SERIES | NAMEPLATE VOLTAGE | MINIMUM INPUT VOLTAGE | MAXIMUM INPUT VOLTAGE | MINIMUM OUTPUT VOLTAGE | MAXIMUM OUTPUT VOLTAGE |
|---|---|---|---|---|---|
| 73000 | 115V | 105V | 125V | 111.2V | 118.8V |
| 73000 | 120V | 111V | 130V | 116.0V | 124.0V |
| 73000 | 220V | 202V | 239V | 212.7V | 227.3V |
| 73000 | 230V | 211V | 250V | 222.4V | 237.6V |
| 73000 | 240V | 220V | 260V | 232.0V | 247.0V |
| 75000 | 120V | 96V | 126V | 114.0V | 126.0V |
| 75000 | 220V | 176V | 231V | 209.0V | 231.0V |
| 75000 | 230V | 184V | 242V | 218.5V | 241.5V |
| 75000 | 240V | 192V | 252V | 228.0V | 252.0V |
| 77000 | 117V | 85V | 125V | 108.8V | 125.2V |
| 77000 | 120V | 87.5V | 128V | 111.6V | 128.4V |
| 77000 | 220V | 160V | 235V | 204.6V | 235.4V |
| 77000 | 230V | 167V | 246V | 213.9V | 246.1V |
| 77000 | 240V | 175V | 255V | 223.2V | 256.8V |

Table 6-2. Line Regulator Tap Change Voltages

| SERIES | NAMEPLATE VOLTAGE | LOW TRIP POINT (APPROXIMATE) | HIGH TRIP POINT (APPROXIMATE) |
|---|---|---|---|
| 73000 | 115V | 112.1V | 118.5V |
| 73000 | 120V | 117.0V | 123.7V |
| 73000 | 220V | 214.6V | 226.9V |
| 73000 | 230V | 224.3V | 237.2V |
| 73000 | 240V | 234.2V | 247.6V |
| 75000 | 120V | 105.6V | 115.0V |
| 75000 | 220V | 193.6V | 210.8V |
| 75000 | 230V | 202.4V | 220.4V |
| 75000 | 240V | 211.2V | 230.0V |
| 77000 | 117V | 96.8V | 109.8V |
| 77000 | 120V | 99.2V | 112.6V |
| 77000 | 220V | 181.4V | 206.0V |
| 77000 | 230V | 190.2V | 215.8V |
| 77000 | 240V | 198.4V | 225.4V |

Table 6-3. Test Equipment Requirements

| FOR | TYPE OF EQUIPMENT REQUIRED | SPECIAL REQUIREMENTS OF EQUIPMENT | SUGGESTED MANUFACTURER AND MODEL |
|---|---|---|---|
| Source of input power | AC voltage source rated at 125 VA or more, variable from zero to the maximum rated input voltage | Continuously variable, sine wave output | Superior Electric 3PN series or equivalent |
| Waveform observation | General purpose dual trace oscilloscope | None | Tektronix model 502 |
| Measuring AC voltage | Digital AC voltmeter | Ability to display AC voltage to 0.1V | Fluke 8100B or equivalent |
| General purpose measurements | Volt-ohmeter | None | Triplett 630-NA or equivalent |
| SCR and Triac breakdown voltage measurement | Transistor Curve Tracer | Measure breakdown voltages to ±600V | Tektronix Type 575 or equivalent |
| Driving power module | DC power supply | 10V, 20mA output | Hewlett Packard 6200B or equivalent |

# SECTION 7

# TROUBLESHOOTING

## 7.1 GENERAL TROUBLESHOOTING PRECAUTIONS

**WARNING**

The circuitry in Topaz line regulators is not isolated from the power line. This presents electrical shock hazards to servicing personnel. It is strongly recommended that a Topaz Ultra-Isolation Transformer or similar isolating device be connected to the input of the line regulator before any work is attempted. As only a few watts are used by an unloaded regulator, a 100 VA isolating device is sufficient for troubleshooting.

**CAUTION**

All troubleshooting should be conducted with no load connected to the regulator.

## 7.2 GENERAL TROUBLESHOOTING CONSIDERATIONS

For troubleshooting, the line regulator may be considered in two parts: the control circuit and the power module. A failure in one part may cause a failure in the other part. For this reason, the two parts should be separated for troubleshooting.

The control assembly and power module may be checked out separately. After a problem has been corrected it is important to be certain that both the control assembly and the power module are functioning properly before attempting to run them as a complete system.

**NOTE**

A logical "High" in this section refers to the voltage of the ACC bus. A logical "Low" refers to the voltage of the -10V bus.

## 7.3 CONTROL ASSEMBLY TROUBLESHOOTING

Remove the control assembly from the regulator. Put it on a bench with a non-metallic top, and connect an isolated, variable AC source between J2 and J1-5.

### 7.3.1 CONTROL POWER SUPPLY

Increase the input voltage from zero to the nominal input level and monitor the voltage on C3. The voltage on C3 should increase with the input up to approximately 10 to 12V. There will be a sharp drop of about one volt when K1 energizes. If the voltage on C3 does not come up, check F1. If F1 is good but C3 still does not charge, it indicates a possible short on the dc bus. This may be caused by a shorted integrated circuit. They may be removed from the circuit one at a time until the short is found. Do not energize the control assembly with U2, U3, or U4 out of the circuit.

After any shorts have been corrected and the control power supply comes up normally, increase the input to 120% of nominal and see that CR4 clamps C3 voltage to less than 15V. Check the voltage on CR5. It should be about 6.2V.

### 7.3.2 CLOCK GENERATOR

With nominal input voltage applied, observe the waveform at U1-1. It should be a rectangular wave that goes low when the input wave is between 180° and 225°. It should go high when the input wave is between 330° and 345°. If this is not observed, check the input to U1-C. U1-7 should have a rectangular wave which is an attenuated and clipped form of the AC line voltage. U1-6 should be at the -6.2V referance voltage. If

the clock generator is working, this signal will be modulated by the clock square waves. Replace U1 if no clock square wave is generated with proper input to U1-C.

If the proper output is observed at U1-1 but no clock pulses are generated at U3-3 or U3-10, replace U3.

If U3 is replaced, but still no clock pulses are generated, it is possible that the input to either U2 or U4 has shorted, causing the problem to appear to be in the clock generator. In this case replace U2 or U4 as required.

### 7.3.3 INPUT COMPARATORS

Set the input voltage to a value 5% below the low trip point as listed under CALIBRATION. Observe the signals at U1-13 and U1-14. They should both be low.

Increase the input voltage to a value midway between the low and high trip points. The signal at U1-13 should be pulses that are high for a portion of the negative half cycle of the input voltage. The signal at U1-14 should be low.

Set the input voltage to a value 5% above the high trip point. Similar pulses should be observed at U1-13 and U1-14, the pulses at U1-13 being slightly wider than at U1-14.

If this is not observed, check the input to the comparators. U1-8 and U1-10 should have negative half sine waves, with peaks greater than -6.2V. U1-9 and U1-11 should be at the -6.2V reference voltage. The output of the comparator should change state every time the signal from the input attenuator crosses the -6.2V level. If this does not occur, replace U1. If this does not correct the problem, replace U2.

### 7.3.4 LOW INPUT VOLTAGE SENSOR

Starting with the input voltage at zero, observe the signal at U1-2. Slowly increase the input voltage to nominal. The signal at U1-2 should start at zero and increase as the input voltage increases. At some point below the rated minimum input voltage, the signal at U2-2 should go low. If this does not occur, replace U1. If this does not correct the problem, replace U3.

Check to see that U3-D inverts the signal from U1-D. If U3 is replaced but it still does not properly invert the signal from U1-D, replace U4.

The signal at U4-15 should follow the signal at U3-4, however it can only change state when clocked by clock phase 2. This can be checked by observing the signals at U4-13 and U4-15 at the same time, and varying the input voltage about the low input sense point and seeing that U4-15 tracks U4-13. Then stop the clock pulse by shorting U1-1 to the -10V bus, and observe that U4-15 holds the state it was in when the clock was stopped.

If U4-15 never changes state, it indicates that U4 or possibly U5 or Q1 is bad. If U4-15 tracks U3-4 even when U1-1 is shorted to the -10V bus, replace U4.

When U4-15 is low, the contacts of K1 should be open and J1-1, J1-2 and J1-3 should all be high.

When U4-15 is high, the contacts of K1 should be closed with a resistance of less than 1 ohm, and the outputs of U5 should be controlled by U4-A and U4-B.

### 7.3.5 DATA STORAGE

Set the input voltage to 5% above the high trip point and see that both input comparators are producing pulsed waves. The signal at U2-3 should be a rectangular wave that goes high when U1-13 goes high and goes low on clock phase 1. U2-11 should produce a rectangular wave that goes high when U1-14 goes high and goes low on clock phase 1.

If this is not observed, replace U2. If replacing U2 does not correct the problem, replace U4.

Next, check the signals at U4-A and U4-B outputs. Vary the input over the input voltage range. The signals at U4-A and U4-B outputs should be steady dc and should change with the input voltage as indicated in this table:

| INPUT VOLTAGE | U4-2 | U4-3 | U4-6 | U4-7 |
|---|---|---|---|---|
| BELOW LOW TRIP POINT | Low | High | High | Low |
| ABOVE LOW TRIP POINT AND BELOW HIGH TRIP POINT | Low | High | Low | High |
| ABOVE HIGH TRIP POINT | High | Low | Low | High |

If these conditions are not observed, replace U4. If that does not correct the problem, replace U5.

### 7.3.6 TAP SELECTION AND DRIVE

The signals at the output of U5 are derived from the data stored in U4-A, U4-B and U4-C. They should only change state when one of the sections of U4 changes state.

Vary the input over the input voltage range and monitor the signals at the output of U5 as indicated in this table:

| INPUT VOLTAGE | U5-6 | U5-9 | U5-10 |
|---|---|---|---|
| BELOW LOW TRIP POINT | Low | High | High |
| ABOVE LOW TRIP POINT AND BELOW HIGH TRIP POINT | High | Low | High |
| ABOVE HIGH TRIP POINT | High | High | Low |

If these conditions are not observed, replace U5.

## 7.4 POWER MODULE TROUBLESHOOTING

Remove the power module from the unit and connect a jumper from P1-4 to P1-5. Using an ohmeter, measure the resistance from E4 to E1, E4 to E2, and E4 to E3. The resistances should be greater than ten megohms. Replace any shorted or leaky triacs or SCR's.

Next connect the circuit illustrated in Figure 7-1.

Turn on the ac power source, but not the 10V supply. None of the lamps should light. Now turn on the dc power supply. The lamp connected to E1 should light. Next switch the 620 ohm resistor from P1-1 to P1-2. The lamp connected to E1 should go out. If the power module came from a 73000 series unit the lamp connected to E3 will now light. If it came from a 75000 or 77000 series unit, the lamp connected to E2 will light. Now switch from P1-2 to P1-3. The lamp that was on will turn off and the lamp which is connected to E2 or E3 and was off, will turn on. Next, turn the 10V power supply off and remove the jumper from P1-4 to P1-5. The lamp connected to E3 should now light.

If any lamp fails to light when it should or stays on all the time this indicates a bad triac or

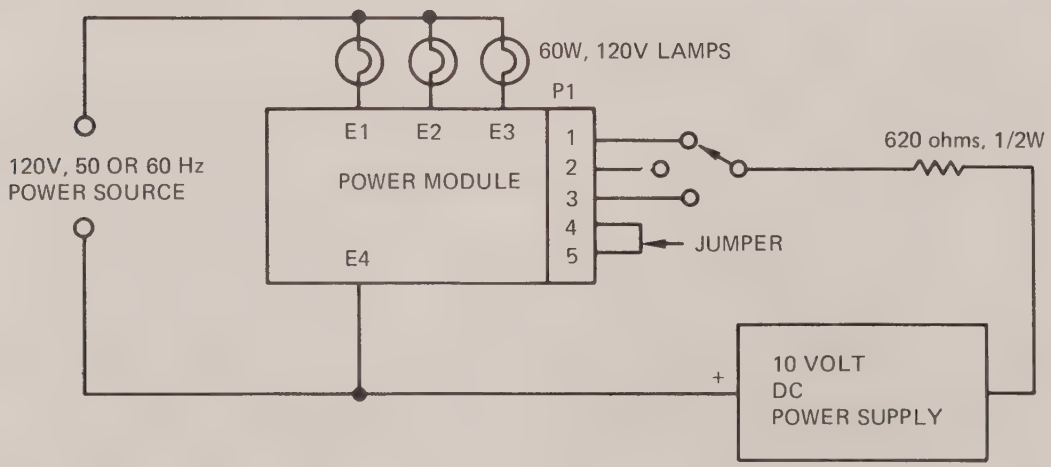


Figure 7-1. Test Setup.

SCR. Checking the circuit with an ohmeter will quickly reveal the faulty component.

After the power module has been checked out as above and the control assembly has been completely checked out, the line regulator should work properly when connected as a system.

If, however, problems are still encountered, a possible source of trouble could be a triac or SCR breaking down under high voltage. To check for this, remove the power module from the circuit and take C1 through C4 off of the power module. The breakdown voltage of each tap switch may now be measured using a transistor curve tracer. Below is a table of the minimum breakdown voltage of each power module.

| POWER MODULE DASH NUMBER | MINIMUM BREAKDOWN VOLTAGE |
|---|---|
| -01 | ± 400V |
| -02 | ± 600V |
| -03 | ± 400V |
| -04 | ± 600V |
| -05 | ± 600V |
| -06 | ± 400V |
| -07 | ± 400V |
| -08 | ± 600V |
| -09 | ± 600V |

## 7.5 TROUBLESHOOTING GUIDE

Table 7-1 provides a quick reference for troubleshooting various symptoms.

Table 7-1. Troubleshooting Guide

| SYMPTOM | PROBABLE CAUSE | RECOMMENDED PROCEDURE | SEE PARAGRAPH |
|---|---|---|---|
| 1. No output | No power at line input terminals | Check power source | 4.2 & 4.3 |
| 2. Failure to regulate for line changes | 1. F1 open<br>2. A2F1 open | Replace F1<br>Replace A2F1 and troubleshoot control | 7.1 through 7.3.6 |
| 3. Circuit breaker trips or fuse opens repeatedly | 1. Output shorted or overloaded | Remove short or overload | |
| | 2. Shorted or open triac or SCR in power | Troubleshoot power module, then the control assembly | 7.3 & 7.4 |
| | 3. Faulty control assembly | Troubleshoot power module, then control assembly | 7.3 & 7.4 |
| 4. Output voltage out of specification | 1. Calibration required | Calibrate unit | 6.3.3 |
| | 2. Faulty control | Troubleshoot control assembly | 7.3 |
| 5. Three-phase unit fails to regulate | 1. Defective regulator on one phase | Troubleshoot faulty regulator | 5.6 |

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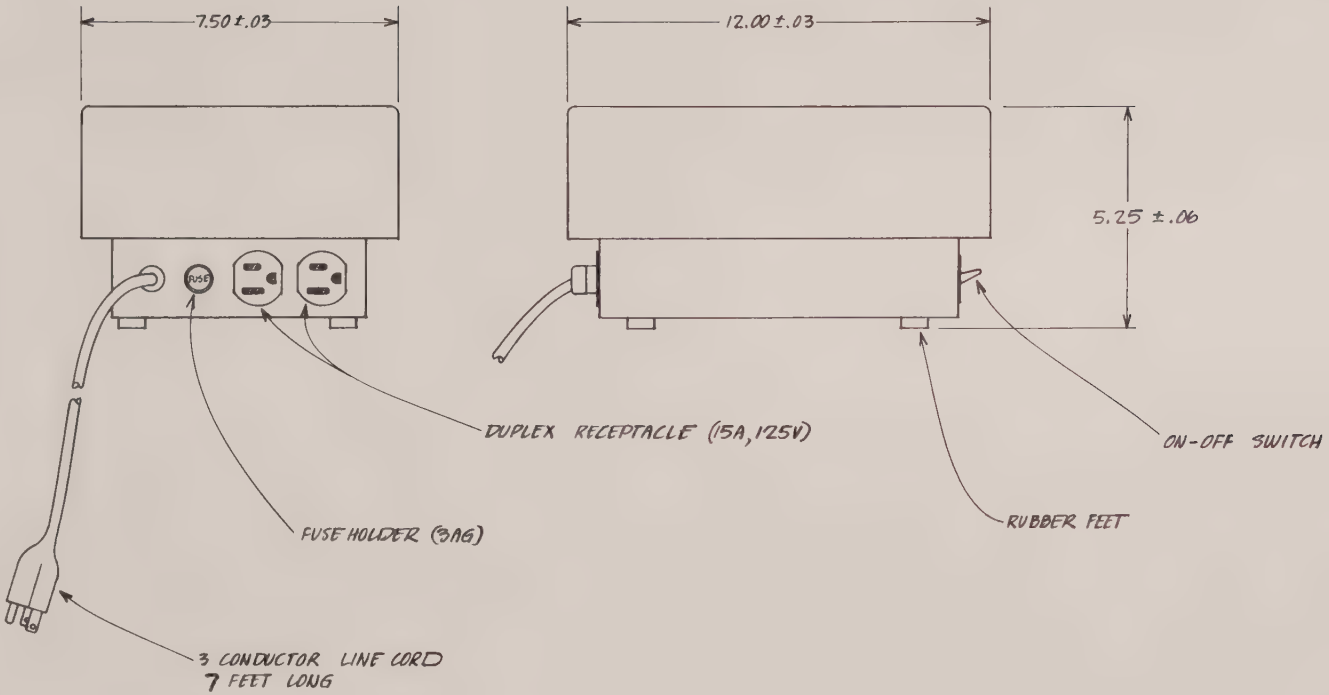
E-053

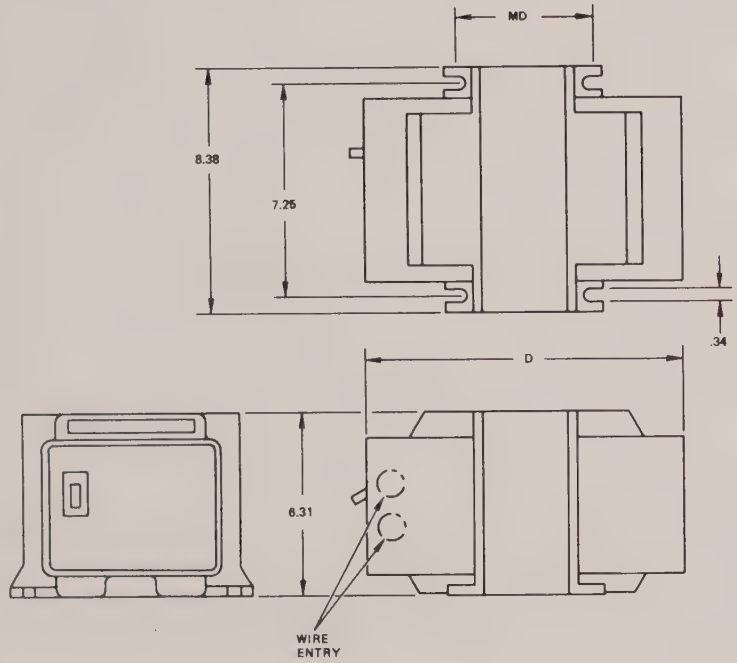
E-014

| REVISIONS | | | | | | |
|---|---|---|---|---|---|---|
| REV | ECO | EFF / DISP | DESCRIPTION | DRAFT | CHECK | APP'D |
| A | — | — | RELEASED | MILLER | | |




| | | | | |
|---|---|---|---|---|
| DRAWN | MILLER | 6-9-76 | INSTALLATION DRAWING, DESK TOP AC LINE REGULATOR | TOPAZ ELECTRONICS SAN DIEGO |
| CHECKED | C. Holmes | 6-10-76 | | C 921-16783 A |
| ENGINEER | C. Holmes | 6-10-76 | | SCALE HALF SHEET 1 OF 1 |
| APPROVED | | | | |
| APPROVED | | | | |

E-016




| PACKAGE | DIMENSION MD (inches) | DIMENSION D (inches) |
|---|---|---|
| B | 2.75 | 9.00 |
| C | 3.75 | 10.00 |
| D | 4.00 | 10.25 |
| E | 4.75 | 11.00 |
| F | 5.25 | 11.50 |
| H | 5.62 | 11.88 |
| I | 6.50 | 12.75 |
| J | 9.25 | 15.50 |
| T | 3.06 | 9.31 |

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| APPROVALS | | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | C. Holmes | 6-21-76 |
| MECHANICAL DESIGN | | |
| PROJECT ENGINEER | C. Holmes | 6-21-76 |

TOLERANCES FOR FINISHED PART
X ± .1 XX ± .03 XXX ± .010

FINISH

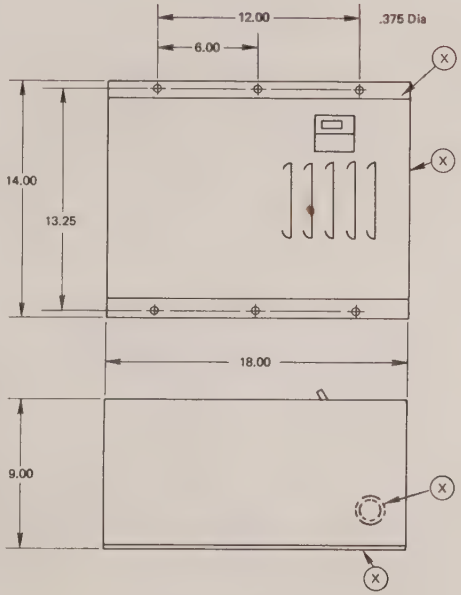
MATERIAL

**TOPAZ ELECTRONICS SAN DIEGO**

INSTALLATION DRAWING,
SINGLE-PHASE AC LINE REGULATORS
IN ENDBELLS

| CODE IDENT. NO. | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| | C | 902-16781 | B |

SCALE | WEIGHT | SHEET OF




PACKAGE G

(X) SHOWS LOCATIONS OF KNOCKOUTS FOR CABLE ENTRY

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| APPROVALS | | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | C. Holmes | 6-21-76 |
| MECHANICAL DESIGN | | |
| PROJECT ENGINEER | C. Holmes | 6-21-76 |

TOLERANCES FOR FINISHED PART
X ± .1 XX ± .03 XXX ± .010

FINISH

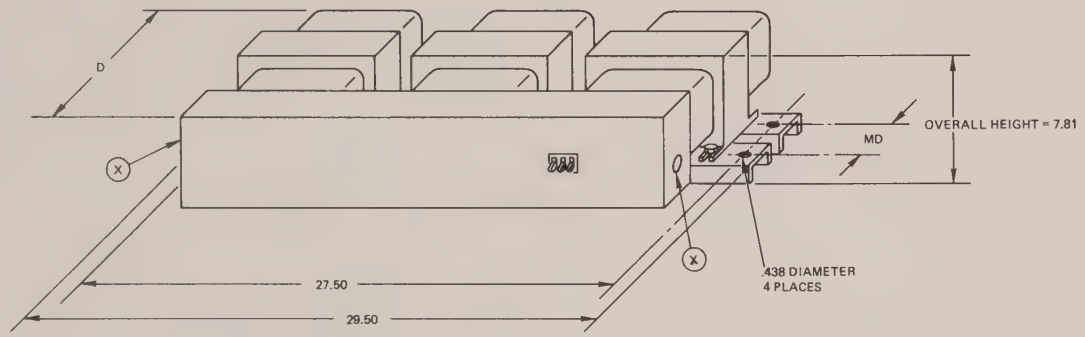
MATERIAL

TOPAZ ELECTRONICS SAN DIEGO

INSTALLATION DRAWING,
SINGLE-PHASE AC LINE REGULATORS
IN WALL-MOUNTING BOX

| CODE IDENT. NO. | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| 06049 | C | 902-16778 | A |

SCALE | WEIGHT | SHEET OF




| PACKAGE | DIMENSION MD | DIMENSION D |
|---|---|---|
| K | 3.75 | 13.0 |
| L | 4.00 | 13.25 |
| M | 4.75 | 14.0 |
| N | 5.25 | 14.5 |
| P | 2.75 | 12.0 |
| Q | 5.62 | 14.9 |
| R | 6.50 | 15.75 |
| S | 9.25 | 18.5 |

(X) SHOWS LOCATIONS OF KNOCKOUTS FOR CABLE ENTRY

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| APPROVALS | | DATE |
|---|---|---|
| DRAWN | | |
| CHECKED | C. Holmes | 6-21-76 |
| MECHANICAL DESIGN | | |
| PROJECT ENGINEER | C. Holmes | 6-21-76 |

TOLERANCES FOR FINISHED PART
X ± .1 XX ± .03 XXX ± .010

FINISH

MATERIAL

**TOPAZ ELECTRONICS SAN DIEGO**

INSTALLATION DRAWING,
THREE-PHASE LINE REGULATORS
IN ENDBELLS

| CODE IDENT. NO. | SIZE | DRAWING NUMBER | REV |
|---|---|---|---|
| 06049 | C | 902-16782 | A |

| SCALE | WEIGHT | SHEET OF |
|---|---|---|

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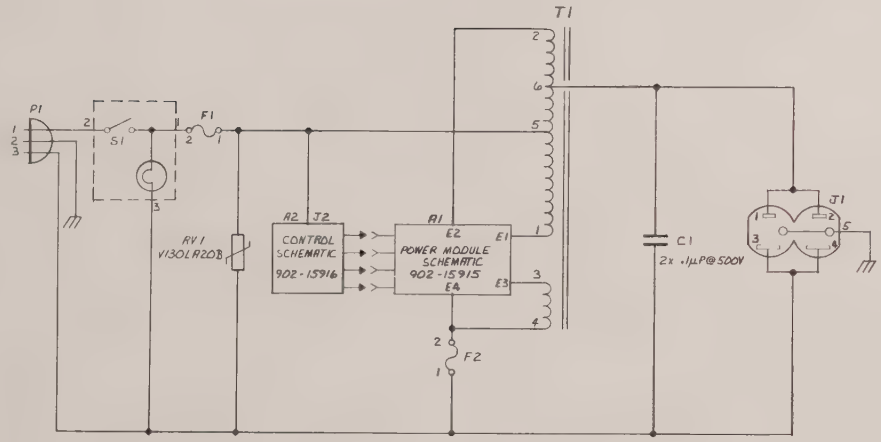
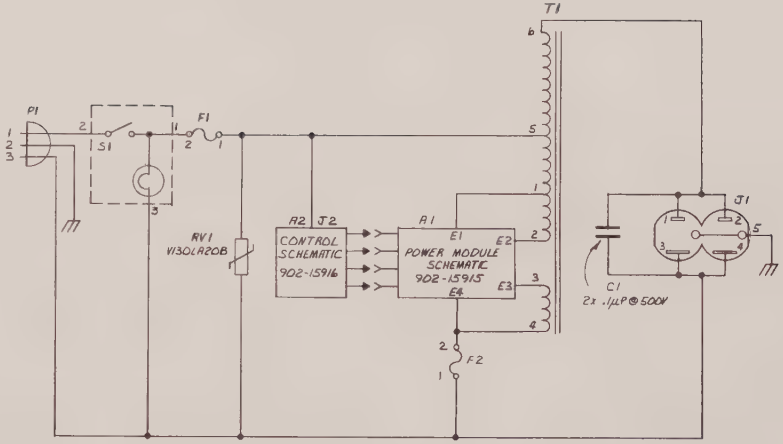
| LINE REGULATOR | T1 | F1 | F2 | POWER MODULE |
|---|---|---|---|---|
| 73198 | 921 16823 | MDA 8 | MDA 1/2 | 902-15899-02 |
| 73199 | 921 16824 | MDA 15 | MDA 1 | -02 |
| 75197 | 921 16825 | MDA 8 | MDA 1 1/4 | -01 |
| 75199 | 921 16826 | MDA 15 | MDA 2 1/2 | -01 |
| 77196 | 921 16827 | MDA 8 | MDA 2 | -01 |
| 77199 | 921 16828 | MDA 15 | MDA 4 | 902-15899-01 |




SCHEMATIC FOR 73198 & 73199




SCHEMATIC FOR
75197 75199
77196 77199

| | | | | |
|---|---|---|---|---|
| DRAWN | F. MULLIGAN | 6-21-76 | SCHEMATIC DIAGRAM DESK TOP A C LINE REGULATORS (L1 FAMILY) | TOPAZ ELECTRONI SAN DIEG |
| CHECKED | C. Holmes | 6-21-76 | | 921-16789 |
| ENGINEER | C. Holmes | 6-21-76 | | SCALE NONE SHEET 1 OF |
| APPROVED | | | | |
| APPROVED | | | | |

E-016

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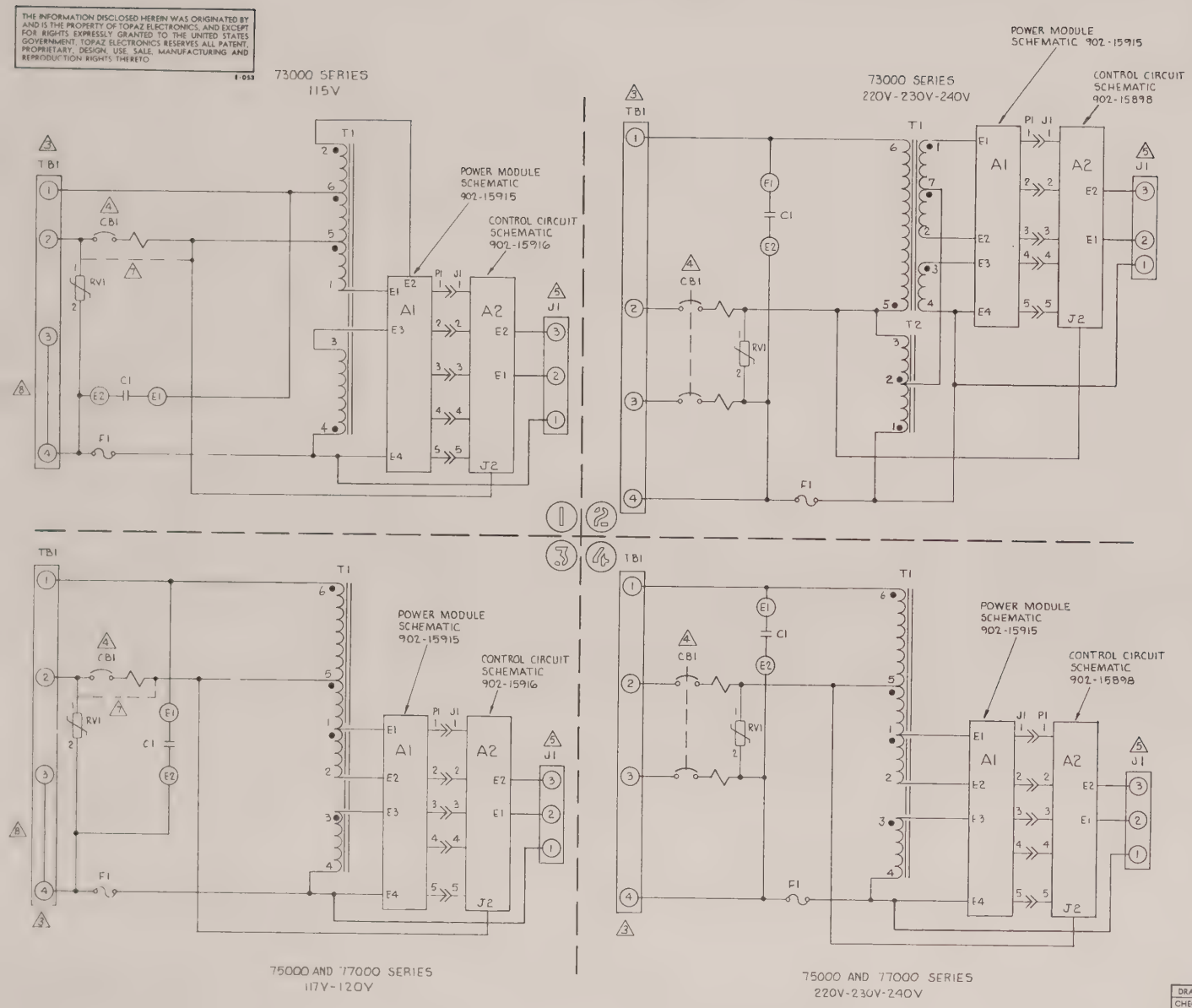


8. JUMPER FROM TBI-3 TO TBI-4 IS OMITTED ON THREE PHASE UNITS.
7. SOLID LINE CONNECTION IS FOR ENDBELL UNITS. DASHED LINE CONNECTION IS FOR BOX UNITS.
6. REFERENCE DESIGNATIONS ARE FOR SINGLE PHASE UNITS. FOR THREE PHASE UNITS, PREFIX REFERENCE DESIGNATION AS FOLLOWS:
   PHASE A REGULATOR – A1
   PHASE B REGULATOR – A2
   PHASE C REGULATOR – A3
5. J2 IS OMITTED ON SINGLE PHASE UNITS.
4. CIRCUIT BREAKER IS OMITTED ON 3Ø UNITS.
3. TBI CONNECTIONS:
   TERMINAL 1: REGULATED OUTPUT
   TERMINAL 2: AC INPUT
   TERMINAL 3: INPUT COMMON
   TERMINAL 4: OUTPUT COMMON
2. SEE 902-15898 FOR A2 SCHEMATIC.
1. SEE 902-15915 FOR A1 SCHEMATIC.

NOTES:

| | | | | |
|---|---|---|---|---|
| DRAWN | D. MISSELDINE | 8 22 75 | SCHEMATIC DIAGRAM, A.C. LINE REGULATOR (L2 FAMILY) | TOPAZ ELECTRONICS SAN DIEGO |
| CHECKED | | 9-8-75 | | 902-15916 E |
| ENGINEER | | 9-17-75 | | SCALE ~ SHEET 1 OF 1 |
| APPROVED | | | | |
| APPROVED | | | | |

E-016

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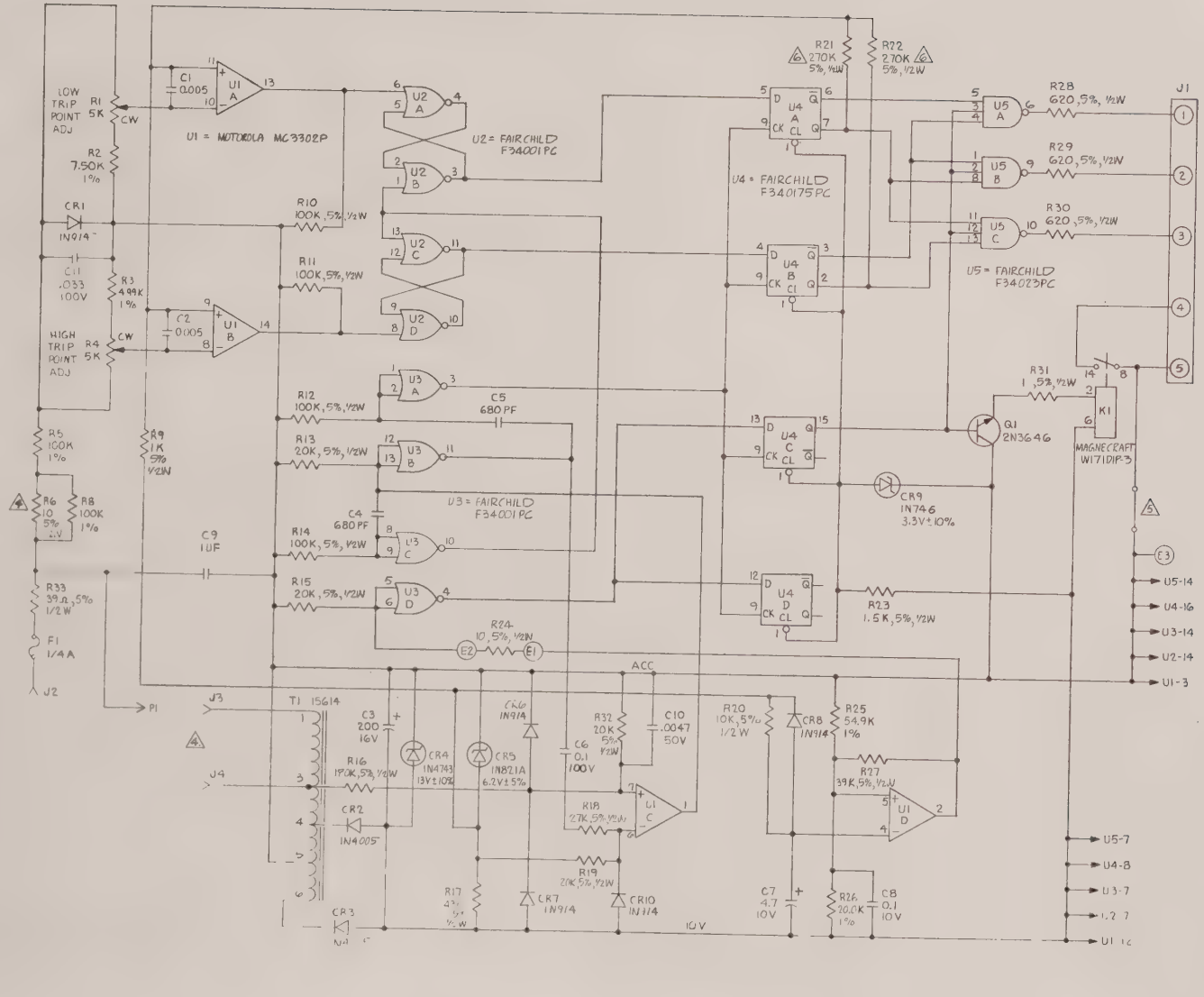
E-003




6 FOR 902-15897-03 ASSEMBLY, R21 & R22 ARE 560K, 5%, 1/2W.

5 OPEN CIRCUIT WHEN USED WITH 923-16906 DRIVER. SHORT CIRCUIT WHEN USED WITH 15899 POWER MODULES.

4 FOR 115/117/120V OPERATION CONNECT P1 TO J4. FOR 220/230/240V OPERATION CONNECT P1 TO J3 AND DELETE R6.

~~3 REMOVE R24 FOR 240 OPERATION~~

2. FOR ASSEMBLY SEE DRAWING 902-15897

1. APPROVED EQUIVALENT COMPONENTS MAY BE SUBSTITUTED.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| DRAWN | A. MISSELDINE 8-21-75 | CONTROL BOARD SCHEMATIC, LINE FREQ. SYNTH | TOPAZ ELECTRONICS SAN DIEGO |
| CHECKED | | | 902-15898 K |
| ENGINEER | | | SCALE NONE SHEET OF |
| APPROVED | | | |
| APPROVED | | | |

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E-068

CHANGE HISTORY APPEARS ON REVISION SHEET 15915

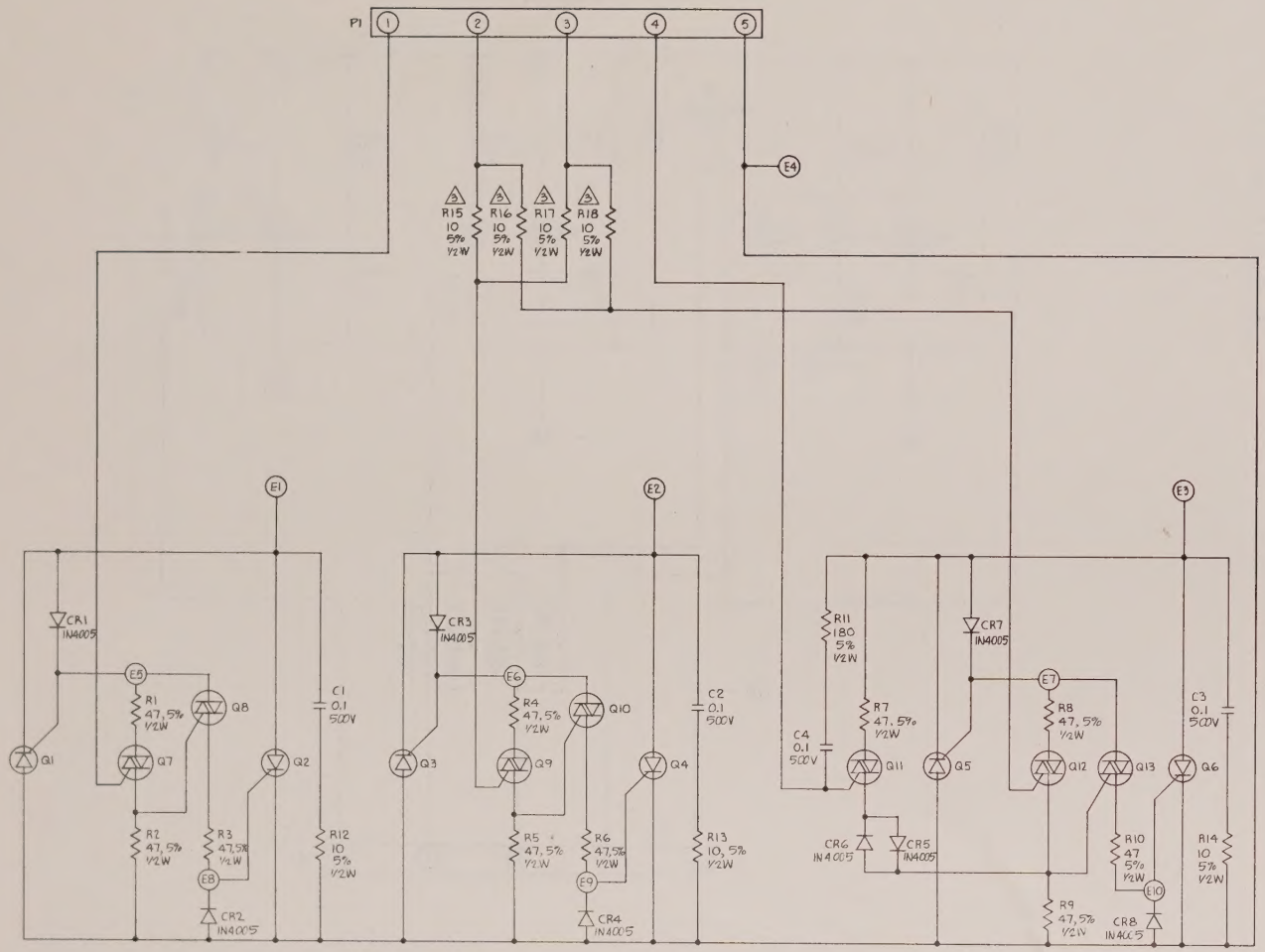


FIGURE 1

| | POWER MODULE ASSEMBLIES | | | |
|---|---|---|---|---|
| | 902-15899-06 | 902-15899-07 | 902-15899-08 | 902-15899-10 |
| Q1 | RCA SG420D OR HUTSON SIPS535 | RCA SG420D OR HUTSON SIPS535 | RCA SG420M OR HUTSON SIPS635 | OMIT |
| Q2 | | | | OMIT |
| Q3 | | | | OMIT |
| Q4 | | | | OMIT |
| Q5 | | | | OMIT |
| Q6 | RCA SG420D OR HUTSON SIPS535 | RCA SG420D OR HUTSON SIPS535 | RCA SG420M OR HUTSON SIPS635 | OMIT |
| Q7 | MOT 2N6073A OR HUTSON T106D2S5D | MOT 2N6073A OR HUTSON T106D2S5D | MOT 2N6073A OR HUTSON T106M2S5D | 2N6073A |
| Q8 | | | | |
| Q9 | | | | |
| Q10 | | | | |
| Q11 | | | | |
| Q12 | | | | |
| Q13 | MOT 2N6073A OR HUTSON T106D2S5D | MOT 2N6073A OR HUTSON T106D2S5D | MOT 2N6073A OR HUTSON T106M2S5D | 2N6073A |

4. FOR Q1-Q13 SEE SCHEDULE ABOVE —

3. FOR 73000 SERIES UNITS DELETE R15 & R18.
   FOR 75000 & 77000 SERIES UNITS DELETE R16 & R17.

2. FOR ASSEMBLY SEE DWG 902-15899, FIGURE 5,7 OR 8.

1. APPROVED EQUIVALENT COMPONENTS MAY BE SUBSTITUTED.

NOTES: UNLESS OTHERWISE SPECIFIED

| | | | | |
|---|---|---|---|---|
| DRAWN | B. MISSELDINE | 8-22-75 | SCHEMATIC, LINE REGULATOR POWER MODULE | TOPAZ ELECTRONICS SAN DIEGO |
| CHECKED | | 9-8-75 | | 902-15915 G |
| ENGINEER | | 9-17-75 | | SCALE ~ SHEET 1 OF 2 |
| APPROVED | | | | |
| APPROVED | | | | |

E-016

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E-053

SEE SHEET 1.

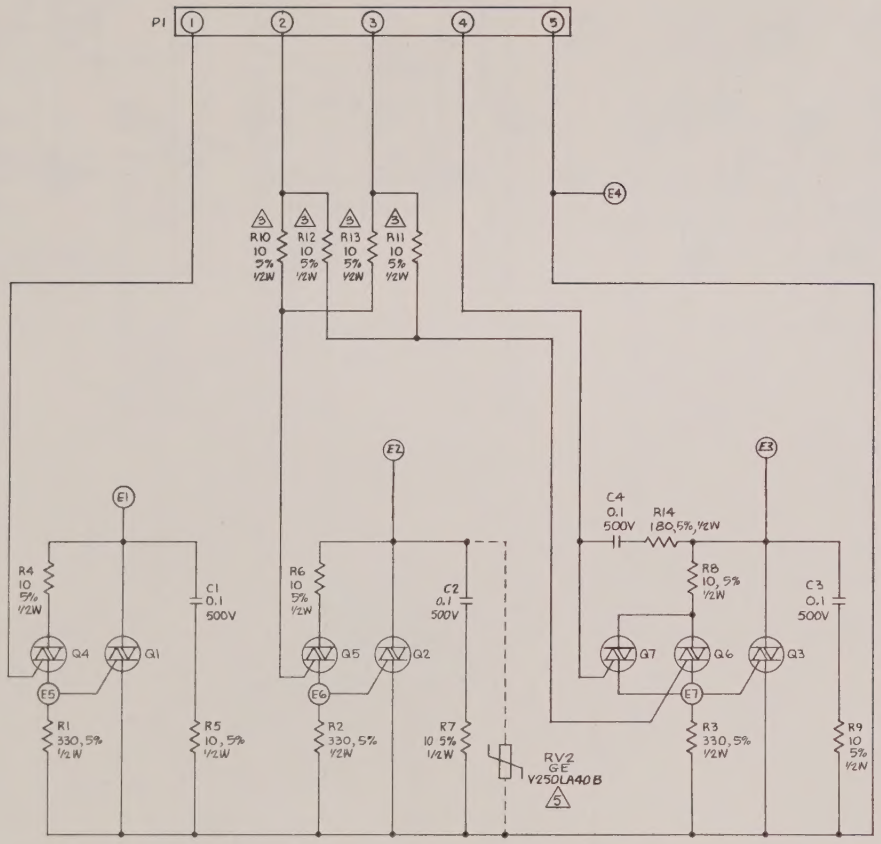


FIGURE 2

5 FOR -11 POWER MODULE ONLY.

| | POWER MODULE ASSEMBLIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 902-15899-11 | 902-15899-01 | 902-15899-02 | 902-15899-03 | 902-15899-04 | 902-15899-05 | 902-15899-09 |
| Q1 | TOPAZ 17012 OR TOPAZ 17011B | ECC GA015L5 OR HUTSON IT415 | ECC GA015L5 OR HUTSON IT615 | TOPAZ 17011A OR TOPAZ 17011B | TOPAZ 17012 OR TOPAZ 17011B | TOPAZ 17012 OR TOPAZ 17011B | TOPAZ 17012 OR TOPAZ 17011B |
| Q2 | ECC GB015L5 OR HUTSON IT615 | ↑ | ↑ | ECC GA015L5 OR HUTSON IT415 | ECC GB015L5 OR HUTSON IT615 | ↑ | ↑ |
| Q3 | ↓ | ECC GA015L5 OR HUTSON IT415 | ECC GA015L5 OR HUTSON IT615 | ECC GA015L5 OR HUTSON IT415 | TOPAZ 17012 OR TOPAZ 17011B | TOPAZ 17012 OR TOPAZ 17011B | TOPAZ 17012 OR TOPAZ 17011B |
| Q4 | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106D25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106D25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106M25D |
| Q5 | ↓ | ↑ | ↑ | ↑ | ↑ | ↑ | ↑ |
| Q6 | | | | | | | |
| Q7 | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106D25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106D25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106M25D | MOT 2N6075A OR HUTSON T106M25D |

4. FOR Q1-Q7 SEE SCHEDULE ABOVE—

3 FOR 73000 SERIES UNITS DELETE R10 & R11.
FOR 75000 & 77000 SERIES UNITS DELETE R12 & R13.

2. FOR ASSEMBLY SEE DWG 902-15899, FIGURE 1,2,3,4 OR 6.

1. APPROVED EQUIVALENT COMPONENTS MAY BE SUBSTITUTED.

NOTES: UNLESS OTHERWISE SPECIFIED.

| | | | | |
|---|---|---|---|---|
| DRAWN | D.MISSELDINE | 8-22-75 | SCHEMATIC, LINE REGULATOR POWER MODULE | TOPAZ ELECTRONICS SAN DIEGO |
| CHECKED | | 9-8-75 | | 902-15915 G |
| ENGINEER | | 9-17-75 | | SCALE ~ SHEET 2 OF 2 |
| APPROVED | | | | |
| APPROVED | | | | |

E-016

MP MASTER
MA29841